ZIMBABWE

MINISTRY OF PRIMARY AND SECONDARY EDUCATION

PHYSICS SYLLABUS

FORMS 5 - 6

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CONTENTS

1.0 PREAMBLE

1.1 INTRODUCTION

This syllabus is designed to put greater emphasis on the mastery and application of Physics. This two- year learning phase will make learners identify, investigate and solve problems in a sustainable manner and prepare them for further studies in Science and Technology. This learning phase will see learners being assessed through continuous assessment and national examinations. The 'A' level Physics syllabus is designed to inclusively cater for all categories of learners.

1.2 RATIONALE

Modern day economies, Zimbabwe included, are driven by Technology and Physics concepts form part of theba-sis. The study of Physics enables learners to be creative and innovative in industry and society that can promote the application of

Physics in industrial processes for value addition. The learning of Physics concepts promotes value addition and beneficiation of natural resources and the harness-ing of available opportunities for enterprise skills.

1.3 SUMMARY OF CONTENT

The 'A' level PhysicsSyllabus will cover theory and practi-cal activities in the following areas:

- Newtonian Mechanics
- Electrodynamics
- Oscillations and Waves
- Physics of Matter
- Modern Physics

1.4 ASSUMPTIONS

It is assumed that:

- The learner has successfully completed Form 3 and 4 Physics Syllabus or any other equivalent syllabus.
- The learner has successfully completed Form 3 and 4 Mathematics syllabus.
- Science clubs are existing and operational in schools.
- Learners are conversant and have access to ICT.
- Well-equipped laboratories are available and safe-ty measures are adhered to.

1.5 CROSS-CUTTING ISSUES

- Environmental issues: climate change and disaster risk management
- Indigenous knowledge systems
- Financial literacy
- Enterprise Education
- Gender
- H I V and Life skills
- Child Protection.
- Team work
- Food security
- Safety health issues

2.0 PRESENTATION OF THE SYLLABUS

The Advanced Level Physics syllabus is a single docu-ment covering Forms 5 and 6. It contains the Preamble, Aims, Syllabus Objectives, Methodology,Topics, Scope and Sequence, CompetencyMatrix, Assessment, and Appendices.

3.0 AIMS

The aims are to enable learners to:

3.1 acquire sufficient understanding and knowl-edge to become confident citizens in a tech-nological world and be able to take or develop an informed interest in matters of scientific importance

3.1.1 recognise the usefulness, and limitations, of scientific method and to appreciate its applica-bility in other disciplines and in everyday life

3.1.2 be suitably prepared for studies beyond A-Level.

3.2 develop abilities and skills that are relevant to the study and practice of Physics,are useful in everyday life, encourage efficient and safe practice as well as effective communication.

3.3. develop attitudes relevant to Physics such as concern for accuracy and precision, objectivity, integrity, the skills of enquiry, initiative, innova-tiveness and inventiveness.

3.4. stimulate interest in, and care for the environ-ment in relation to the environmental impact of Physics and its applications.

3.5. promote an awareness, as guided by Ubuntu/Unhu/Vumunhu philosophy, that:

- the study and practice of Physics are co-operative and cumulative activities, and are subject to social, economic, technological, ethical and cultural influences and limitations.
- the implications of Physics may be both beneficial and detrimental to the individual, the community and the environment.

3.6 create a sustained interest in Physics so that the study of the subject is enjoying and satisfying.

4.0 SYLLABUS OBJECTIVES

Learners should be able to:

1. demonstrate knowledge about physical phenomena, facts, laws, definitions and concepts of Physics.
2. follow instructions in practical work in order to manipulate, record observations and analyse data to confirm or establish relationships.
3. measure and express physical quantities to a given level of accuracy and precision.
4. solve real life problems using the scientific method.
5. use ICT to simulate Physics phenomena, present and analyse Physics data
6. apply safety measures in all practical work.
7. usePhysicsconcepts, principles and techniques in the conservation and sustainable use of the environment.

5.0 METHODOLOGY

The teaching and learning of Physics should be based on learner-centredapproach. The following methods are recommended:

- Planned experiments
- Learning by discovery
- Problem based learning
- Individual and group work
- Educational tours
- Project based learning
- Design based learning
- E-learning such as simulation
- Resource person(s)

TIME ALLOCATION

A minimum of12 periods of 35 minutes each in a week should be allocated as double periods for adequate coverage of the syllabus. A block of 4 periods should be allocated to practicalwork.

6.0 TOPICS

1. General Physics
2. Newtonian Mechanics
3. Oscillations and Waves
4. Electricity and Magnetism
5. Electronics
6. Matter
7. Modern Physics

7.0 SCOPE AND SEQUENCE

TOPIC	FORM 5	FORM 6
1.0 General Physics	▪ Physical Quantities and Units ▪ Errors and uncertainties	
2.0 Newtonian Mechanics	▪ Kinematics ▪ Dynamics ▪ Forces ▪ Work, Energy and Power ▪ Circular Motion ▪ Gravitational Field	
3.0 Oscillations and Waves	▪ Oscillations ▪ Waves ▪ Superposition	
4.0 Electricity and Magnetism	▪ Electricity ▪ D.C. Circuits ▪ Electric fields ▪ Capacitance	
		▪ Electro magnetism ▪ Electromagnetic Induction ▪ Alternating Currents

TOPIC	FORM 5	FORM 6
5.0 Electronics		▪ Analogue Electronics ▪ Digital electronics
6.0 Matter		▪ Phases of Matter ▪ Deformation of Solids ▪ Temperature ▪ Thermal Properties of Materials ▪ Ideal gases ▪ Non-viscous Fluid Flow ▪ Transfer of Thermal Energy
7.0 Modern Physics		▪ Charged Particles ▪ Quantum Physics ▪ Atomic Structure ▪ Radioactivity ▪ Communication

8.0 COMPETENCE MATRIX

FORM 5

1.0 GENERAL PHYSICS

TOPIC	OBJECTIVES **Learners should be able to**:	UNIT CONTENT (SKILLS, ATTITUDES AND KNOWLEDGE)	SUGGESTED LEARNING ACTIVITIES AND NOTES	SUGGESTED RESOURCES
1.1 Physical quantities and units	• express derived units as products or quotients of the base units and use the named units listed in the appendix • use base units to check the homogeneity of physical equations • derive physical equations using base units • demonstrate understanding and use the conventions for labelling graph axes and table columns • use the following prefixes and their symbols to indicate decimal sub-multiples or multiples of both base and derived units: pico (p), nano (n), micro (μ), milli (m), centi (c), deci (d), kilo (k), mega (M), giga (G), tera (T) • determine the resultant of two or more coplanar vectors • represent a vector as two perpendicular components	• Physical quantities and equations • Base Quantities • SI units • Data presentation • Vectors	• Deriving units from base units • Carrying out planned experiment in measurement • checking of the homogeneity of physical equations • Measuring and Expressing physical quantities in multiple/sub multiple units • adding and subtracting two or more coplanar vectors • Resolving vectors	• "ASE publication SI Units, Signs, Symbols and Abbreviations" (The ASE Companion to 5-16 Science, 1995).
1.2 Errors and uncertainties	• distinguish between systematic and random errors • differentiate between precision and accuracy • assess the uncertainty in a derived quantity by simple addition of actual, fractional or percentage uncertainties (a rigorous statistics treatment is not required)	• Data presentation • Errors • uncertainties	• Differentiating between systematic and random errors. • Demonstrating precision and accuracy • Combining errors	• Graphs • ICT

2.0 NEWTONIAN MECHANICS

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (SKILLS, ATTITUDES AND KNOWLEDGE)	SUGGESTED LEARNING ACTIVITIES AND NOTES	SUGGESTED RESOURCES
2.1 Kinematics	• derive from the definitions of velocity and acceleration, equations which represent uniformly accelerated motion in a straight line • solve problems using equations which represent uniformly accelerated motion in a straight line, including the motion of bodies falling in a uniform gravitational field without air resistance • describe and explain motion due to a uniform velocity in one direction and a uniform acceleration in a perpendicular direction (Projectiles) • solve problems using standard equations for projectile motion • identify and explain some everyday examples of rectilinear and non-linear motion	• Rectilinear motion $v = u + at$ $v^2 = u^2 + 2as$ $s = ut + \frac{1}{2}at^2$ • Non-linear motion	• Deriving equations of motion • Solving problems using equations of linear motion • Analysing projectile motion • Solving projectile motion problems	• ICT
2.2 Dynamics	• define linear momentum as the product of mass and velocity • solve problems using the	• Linear momentum	• Explaining the use of force-time graphs	• ICTs • Trollies •

	relationship F= ma, appreciating that acceleration and force are always in the same direction • state the principle of conservation of momentum • use the principle of conservation of momentum on simple applications including elastic and inelastic collisions between two bodies in one dimension (calculations involving the use of coefficient of restitution are not required) • recognise that, for a perfectly elastic collision, the relative speed of approach is equal to the relative speed of separation • define impulse as 'change in momentum' • explain the significance of area under a force - time graph • describe applications of Newton's laws of motion and conservation of linear momentum	• Impulse • Newton's laws of motion	• Demonstrating elastic and inelastic collisions using ICT simulations • Determining area under force-time graph	
2.3 Forces	• describe the forces acting on a mass in motion or at rest • state and explain the	• Types of forces • Equilibrium of forces	• Using the vector triangle to represent forces in	• Spring balances • mass • Burette/ long glass tube • Metal Beads

	origin of the upthrust acting on a body in a fluid • calculate the upthrust in terms of the weight of the displaced fluid (Archimedes Principle) • describe friction as a force which opposes motion (knowledge of coefficient of friction and viscosity is required)	• Centre of gravity • Turning effects of forces	equilibrium • Investigating "three force" equilibrium using spring balances and weights	• Meter rule • Liquid paraffin • Masking tape/maker • Stop watch • •
	• use Stoke's law to explain quantitatively how a body falling through a viscous fluid under laminar conditions attains a terminal velocity • describe an experiment, based on the measurement of terminal velocity, to determine the viscosity of a liquid	• Terminal velocity.	• Carrying out experiments to measure terminal velocity • Carrying out experiments to determine the viscosity of a liquid	
	• describe a couple as a pair of forces tending to produce rotation only • define and use the moment of a force and the torque of a couple • outline the conditions for a system to be in equilibrium • describe everyday application of forces in equilibrium		• Determining the moment and torque of a couple	

2.4 Work,energy and power	• define work in terms of the product of a force and displacement in the direction of the force • calculate the work done in a number of situations including the work done by a gas which is expanding against a constant external pressure: $W = p\Delta V$ • derive, from the equations of motion, the formula $E_k = \frac{1}{2}mv^2$ • recall and apply the formula $E_k = \frac{1}{2}mv^2$ • distinguish between gravitational potential energy, electric potential energy and elastic potential energy • derive, from the defining equation $W = F\Delta s$, the formula $E_p = mgh$ for potential energy changes near the Earth's surface • use the formula $E_p = mgh$ for potential energy changes near the Earth's surface • explain the concept of internal energy • explain that there are energy losses in practical devices and use the concept of efficiency • relate power to work done and time taken using appropriate examples • derive and use power as	• Energy conversion and conservation • Work • Potential energy, kinetic energy and internal energy • Power	• Measuring work required for various tasks • Estimating kinetic energy of various objects • Investigating speed of a falling object (gravitational potential • Measuring power output of an electric motor • Visiting Power stations	• Force metre • Stop watch • Slotted masses • Light gates/ motion sensors • Metre rule/ tape measure • Electric motor • Solar panels • Solar bulbs

	the product of force and velocity • describe and explain everyday examples of energy conversion (e.g. hydro, thermal, solar, wind, chemical electric power, and environmental concerns)		• Using solar panels for heating and lighting	
2.5 Circular Motion	• express angular displacement in radians • define angular velocity, centripetal force and centripetal acceleration • understand the use of the concept of angular velocity • derive and use $v = r\omega$ • describe qualitatively the motion in curved path due to a perpendicular force • explain the centripetal acceleration in the case of uniform motion in a circle • Derive and use centripetal acceleration $a = v^2/r$ and $a = r\omega^2$ • use centripetal force $F = mv^2/r$, $F = mr\omega^2$ • describe and explain everyday examples of motion in a circle (to include banked roads, geostationary orbits and their applications)	• Kinematics of uniform circular motion • Centripetal acceleration • Centripetal force	• Deriving the equations of circular motion • Demonstrating circular motion in vertical and horizontal circles using buckets with water. • Visiting centres where circular motion is used. • Riding bicycles at round about. • Deriving and using equations when solving a problem.	• Bucket • String • Pendulum • ICTs • Bicycles
2.6 Gravitational Field	• show an understanding of	• Gravitational field	• Simulating planetary	• ICT tools

	a gravitational field as a field of force • define gravitational field strength as force per unit mass • state and use Newton's law of gravitation in the form $F = Gm_1m_2/r^2$ • analyse circular orbits in inverse square law fields by relating the gravitational force to the centripetal acceleration it causes • derive from Newton's law of gravitation and the definition of gravitational field strength, the equation $g = Gm/r^2$ for the gravitational field strength of a point mass • use the equation $g = Gm/r^2$ for the gravitational field strength of a point mass • explain that on the surface of the Earth g is approximately constant and is called the acceleration of free fall • describe an experiment to determine the acceleration of free fall using a falling body • define potential at a point as the work done in bringing unit mass from infinity to the point • use the equation $\varphi = -Gm/r$ for the potential in	• Force between point masses • Field of a point mass • Field near the surface of the earth • Gravitational potential	motion using ICT tools. • Carrying out experiments using falling objects and laser beams and timers.	• Electronic timers • Motion sensors.

	the field of a point mass • describe and explain everyday applications of the gravitational force of attraction (include satellite and period of rotation)			

3.0 OSCILLATIONS AND WAVES

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (SKILLS, ATTITUDES AND KNOWLEDGE)	SUGGESTED LEARNING ACTIVITIES AND NOTES	SUGGESTED RESOURCES
3.1 Oscillations	• describe simple examples of free oscillations such as the simple pendulum, spring mass system and torsional pendulum • explain the terms amplitude, period, frequency, angular frequency and phase difference • express period in terms of frequency and angular frequency, $f=1/T$ and $T=2\pi/f$ • express graphically the changes in displacement, velocity and acceleration for a simple oscillator • recognise and use: $v=v_o\cos wt$ $v=\pm w(x_o^2 - x^2)^{1/2}$ • prove that for simple oscillations $a=-w^2x$ • recall and use $x = x_0 \sin wt$ as a solution to the equation $a = -w^2 x$ • describe analytically and graphically the inter-change between kinetic and potential (gravitational/elastic) energy in a simple	• Simple harmonic motion.	• Carrying out experiments involving oscillatory sytems. • Deriving $a =- w^2x$. • Solving problems using the listed equations • Drawing and analysing displacement, velocity and acceleration graphs.	• Spring mass system • Simple pendulum • Loaded cantilever • Barton pendulums • Stop watches

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (SKILLS, ATTITUDES AND KNOWLEDGE)	SUGGESTED LEARNING ACTIVITIES AND NOTES	SUGGESTED RESOURCES
	oscillator • describe examples of damped oscillations such as car suspension systems and moving coil meters • describe graphically the degrees of damping • describe practical examples of forced vibrations and resonance • depict graphically how the amplitude changes with frequency near the natural frequency of an oscillation system • state examples where resonance is useful and where it is a nuisance	• Damped and forced oscillations. • Resonance	• Using Barton pendulums to analyse resonance	
3.2 Waves	• define critical angle, c and total internal reflection • derive and use the equation $n = 1/\sin c$ • explain the use of total internal reflection in fibre optics transmission • appreciate the advantage of fibre optics transmission • understand and use the terms speed of a wave, wave length, frequency, period, amplitude and phase difference	• Reflection and refraction of light. • Polarisation • Electro-magnetic waves	• Simulating ICT. • Deriving listed equations, visiting and using them to solve problems. • Using polaroids to show polarisation	• ICT tools • Polaroids • Resource persons • CRO • Ripple tank and diffraction grating

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (SKILLS, ATTITUDES AND KNOWLEDGE)	SUGGESTED LEARNING ACTIVITIES AND NOTES	SUGGESTED RESOURCES
	• deduce the definition of speed, frequency and wave length • use the equation $v = f\lambda$ • understand polarisation as a phenomenon association with transverse waves only • describe the main features of electromagnetic spectrum and characteristics of electromagnetic waves • describe the main features of the x-ray tube and the production of x-rays by electron bombardment on a metal target (no need for equations) • understand the use of x-rays in imaging internal structures, including a simple analysis of the causes of sharpness and contrast • understand the use of x-rays in the treatment of malignancy and identification of minerals • use equation $I = I_0e^{-ux}$ for the attenuation of x-rays in matter • understand the purpose of computed tomography	• X-ray production • X-ray tube intensity and hardness. • Uses of x-rays. • X-ray diffractometer or x-ray diffraction. • Diffraction. • Interference. • Two source interference pattern • Diffraction order	• Visiting x-ray and C.T. Scan centre. • Measuring wave length. • Solving problems using listed formulae. • Carrying out experiments on diffraction.	

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (SKILLS, ATTITUDES AND KNOWLEDGE)	SUGGESTED LEARNING ACTIVITIES AND NOTES	SUGGESTED RESOURCES
	or understand the principles of CT scanning • distinguish between stationery and progressive waves • determine the wave length of sound using stationary waves understand how the image of an 8 voxel cube can be developed using CT scan	• CT scanning		
3.3 Superposition	• explain the principle of super position in simple application • explain and identify nodes and antinodes • show an understanding of experiments which demonstrate two-source interference (Young's two-slit experiment • explain the term coherence • explain the conditions required if two source interference fringes are to be observed • use the equation,for fringe spacing $x = \lambda D/a$ • demonstrate experiments on diffraction use the formula $n\lambda = d\sin\theta$ to determine the wave		• Experimenting on super position and stationery wave formation.	• ICT tools • Signal generator • Microphone • Slinky spring • Rope • Meter rule

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (SKILLS, ATTITUDES AND KNOWLEDGE)	SUGGESTED LEARNING ACTIVITIES AND NOTES	SUGGESTED RESOURCES
	length of light			

4.0 ELECTRICITYAND MAGNETISM

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (Skills. Attitudes and knowledge)	Suggested learning activities and notes	Suggested resources
4.1 Electricity	• describe practical applications of electrostatic phenomena in photocopying, paint spraying and dust attraction • define the charge and the coulomb • define potential difference and the volt • solve problems using $Q=It$, $V=W/Q$ $P=VI$, $P=V^2/R$and $P = I^2 R$ • define resistance and the ohm • recall and solve problems using $R=\rho l/A$ • define e.m.f. in terms of energy transferred by a source in driving unit charge round a complete circuit • use appropriate equipment in trouble shooting electrical circuits • distinguish between e.m.f. and p.d. in terms of energy considerations • describe the effects of	• Simple electrostatic phenomena • Electric current • Potential difference • Resistance and resistivity • Circuit faults • Electromotive faults • Power	• Carrying visits to places where electrostatics spray painting, photocopying and dust attraction are done. • Solving circuit problems using listed equations • Taking measurement to distinguish between e.m.f. and p.d. • Identifying and fixing	• Resource person • Photocopier • ICT tools • Power source • Carbon resistors • Voltmeters • Ammeters • Constantan wires • Multi-meter • C.R.O.

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (Skills. Attitudes and knowledge)	Suggested learning activities and notes	Suggested resources
	internal resistance of a source of e.m.f. on terminal potential difference and output power • calculate the internal resistance of a source of e.m.f. using $V=E-Ir$ • determine practically the internal resistance (r) of a power source	• Internal resistance	faulty circuits. • Testing basic circuit components • Carrying out experiments to measure internal resistance.	

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (Skills. Attitudes and knowledge)	Suggested learning activities and notes	Suggested resources
4.2 D.C. Circuits	• state Kirchhoff's first law and explain the link to conservation of charge • state Kirchhoff's second law and explain the link to conservation of energy • derive, using Kirchhoff's laws and formula for the combined resistance of two or more resistors in series and parallel • apply Kirchhoff's laws to solve simple circuit problems • use potential divider as a source of variable p.d. • describe and explain the use of thermistor, LDR and strain gauge in potential divider circuits to provide voltage representatives of physical quantities • use the principle of the potentiometer as a means of comparing potential differences	• Kirchhoff's laws. • Use potential divider. • Principle of the potentiometer	• Solving problems using Kirchhoff's laws. • Using Kirchhoff's laws to derive formula for resistors. • Using potential divider in circuits. • Carrying out experiments to determine unknown e.m.fs and to compare p.ds.	• ICT tools • Power sources • Carbon resistors • L.D.R • Thermistor • Strain gauge • Potentiometer • Galvanometer • Jockey
4.3 Electric fields	• describe an electric field as an example of a field of force and define electric field	• Concept of an electric field and field strength.	• Solving problems using stated formulae	• ICT tools

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (Skills. Attitudes and knowledge)	Suggested learning activities and notes	Suggested resources
	strength as force per unit positive charge • use $E = V/d$ to calculate the field strength of the uniform field between charged parallel plates in terms of potential difference and separation • calculate the forces on charges in uniform in electric fields • describe the effect of a uniform electric field on the motion of charged particles • use Coulomb's law in the form $F=Q_1 Q_2/(4\pi \varepsilon_0 r^{2)}$ for the force between two point charge in freed space of air • use $E=Q/4 \pi \varepsilon_0 r^2$ for the field strength of a point charge in free space or air • define potential at a point in terms of work done in bringing a unit positive charge from infinity to the point • state that the field strength of the field at a point is numerically equal to the potential gradient at that point • use the equation $V= Q/4\pi\varepsilon_0 r^2$ for the potential in the field of a point charge • compare qualitative and quantitative aspect of	• Uniform electric fields. • Force between point charges. • Electric field of a point charge. • Electric potential. • Potential gradient.	• Simulating an electric field • Indicating similarities between electric and gravitational fields.	

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (Skills. Attitudes and knowledge)	Suggested learning activities and notes	Suggested resources
	electric and gravitational fields			
4.4 Capacitances	• describe the function of capacitors in simple circuits • define capacitance and the farad • solve problems using $C=Q/V$ • derive, using the formulae $C=Q/V$, conservation of charge and edition of p.ds, the formulae for capacitors in series and parallel • solve problems using formulae for capacitors in series and in parallel • deduce the area under a potential-charge graph, the equation $W=1/2QV$ and hence $W=1/2\ CV^2$ • describe charging and discharging of capacitors in RC circuits	• Capacitors and capacitance • Energy stored in a capacitor.	• Discussing the use of capacitors in electronic circuits • Solve problems using the stated formulae. • Derive $W=1/2\ QV$ using graphs • Charging and discharging capacitors in circuits.	• Resistors • Capacitors • Power source • Ammeters

FORM 6

4.5 Electromagnetism	• explain that a force might act on a current • carrying conductor placed in a magnetic field • solve problems using the equation $F = BIL \sin\theta$ with directions as interpreted by Fleming's left hand rule • define magnetic flux density and the testla	• Force on current-carrying conductor • Force on a moving charge. • Magnetic fields due to currents	• Carrying out experiment to verify $F=BIL \sin\theta$ • Solving problems using $F=BIL \sin\theta$ and $F = Bqv \sin\theta$. • Determining direction using Fleming's left hand rule.	• Permanent magnets • Metallic rods • Rider • Half meter rule • Protractor • Power pack • Ammeter • Electronic balance • Computer • Solenoid

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (Skills. Attitudes and knowledge)	Suggested learning activities and notes	Suggested resources
	• demonstrate how the force on a current-carrying conductor can be used to measure the flux density of a magnetic field using a current balance • predict the direction of the force on a charge moving in a magnetic field • solve problems using $F = Bqv\sin\theta$ • sketch flux patterns due to a long straight wire, a flat circular coil and a long solenoid • show that the field due to a solenoid may be influenced by the presence of a ferrous core • describe the principle of the electro magnet and state its uses • explain the force between current carrying conductors and predict the direction of the force • describe and compare the forces on mass, charge and current in a gravitational, electric and magnetic fields, as appropriate • describe how a calibrated Hall probe can be used to measure flux density	• Electromagnet. • Force between current- carrying conductors. • Hall probe.	• Carrying out experiment to determine flux density using current balance • Sketching flux field patterns. • Simulating force on a moving charge in B field using computers • Investigating the effect of ferrous core in a solenoid • Measuring flux density using a calibrated Hall probe.	• Soft iron core
4.6 Electromagnetic Induction	• define magnetic flux and the Weber	• Laws of electromagnetic induction	• Solving problems using $\varphi = BA$.	• Dynamo • Voltmeter

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (Skills. Attitudes and knowledge)	Suggested learning activities and notes	Suggested resources
	• solve problems using $\varphi = \boldsymbol{BA}$. • define magnetic flux linkage • deduce from appropriate experiments on electromagnetic induction - that a changing magnetic flux can induce an e.m.f. in a circuit, - that the direction of the induced e.m.f. opposes the change producing it - the factors affecting the magnitude of the induced e.m.f.	- Faraday's law - Lenz law	• Measuring voltage and current generated by a dynamo • Verifying Lenz law	• Ammeter • Solenoid/ coil • Magnet • Center zero galvanometer
4.7 Alternating Currents	▪ define and use the terms period, frequency, peak value and root-mean-square(r.m.s) value as applied to an alternating current or voltage. ▪ deduce that the mean power in a resistive load is half the maximum power for a sinusoidal alternating current ▪ represent an alternating current or an alternating voltage by an equation of the form $x = x_o \sin\omega t$ ▪ distinguish between r.m.s and peak values and solve problems using the relationship $I_{rms} = I_o/\sqrt{2}$for the sinusoidal case ▪ show an understanding of	• Characteristics of alternating currents • The transformer • Transmission of electrical energy • Rectification	• using a CRO to display and measure peak voltage/current and determining root-mean-square • investigating the effect of number of turns on output voltage/current • making prototype transformer ▪ connecting diodes to display half-wave and full-wave rectification.	• CRO • A.C power source • prototype transformer • diodes • CRO • A.C power source

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (Skills. Attitudes and knowledge)	Suggested learning activities and notes	Suggested resources
	the principle of operation of a simple iron-cored transformer and solve the problems using $N_s/N_p = V_s/V_p = I_p/I_s$ for an ideal transformer. ▪ explain the use of oil in transformer ▪ show an appreciation of the scientific and economic advantages of alternating current and of high voltages for the transmission of electric energy ▪ state the scientific and economic advantages of alternating current and of high voltage ▪ distinguish graphically between half-wave and full-wave rectification ▪ explain the use of a single diode for the half-wave rectification of an alternating current ▪ explain the use of four diodes (bridge rectifier) for the full-wave rectification of an alternating current. ▪ analyse the effect of a single capacitor in smoothing, including the effect of the value - of capacitance in relation to the load resistance			
5.0. ELECTRONICS	▪ describe the use of the light-	▪ Transducers	• Constructing circuits to	• operational

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (Skills. Attitudes and knowledge)	Suggested learning activities and notes	Suggested resources
5.1 Analogue Electronics	emitting diode (LED), the buzzer and the relay as output devices ▪ describe the properties of the ideal amplifier as a comparator ▪ explain the use of an operational amplifier as a comparator ▪ discuss the principles of negative and of positive feedback in an amplifier ▪ describe the circuit diagrams for both the inverting and the non-inverting amplifier for single signal input ▪ use the virtual earth approximation to derive an expression for the gain of inverting amplifiers ▪ use expression for the voltage gain of inverting and non-inverting amplifiers ▪ discuss the effect of negative feedback on the gain and on the bandwidth of an operational amplifier ▪ describe the use of an operational amplifier as a summing amplifier in the inverting mode ▪ describe the use of an operational amplifier as a voltage follower ▪ describe the use of an operational amplifier as a non-inverting Schmitt-trigger,	▪ The ideal operational amplifier ▪ Operational amplifier circuits	show functioning of control systems e.g burglar alarms, automated street lightning system, • Assembling circuits to show the effect of negative feedback on gain and bandwidth	amplifiers ICs • circuit boards • LED • Buzzer • relay • CRO • carbon resistors • Signal generator

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (Skills. Attitudes and knowledge)	Suggested learning activities and notes	Suggested resources
	with positive feedback provided by a potential divider			
5.2 Digital Electronics	▪ describe the function of each of the following gates: NOT, AND, NAND, OR, NOR and represent these functions by means of truth tables (limited to a maximum of two inputs, where appropriate) ▪ describe how to combine AND, NOT and OR gates, or NAND gates only, to form EXOR and EX-NOR gates ▪ analyse circuits using combinations of logic gates to perform control functions ▪ explain how to construct and interpret truth tables for combinations of logic gates ▪ describe the function of simple electronic devices and systems which are found in the home, in industry and in communications ▪ appreciate the impact of electronic devices and systems on domestic and industrial activities ▪ appreciate the impact of electronic devices and systems on modern communications	▪ Logic gates ▪ Logic gates combinations ▪ The impact of electronics in society and industry	• Assembling circuits to show functionality of NOT, AND, NAND, OR, NOR • Making circuits with a mesh of logic gates to open a safe, or other control functions • Discussing and explaining how electronics has made life easier	• ICs • power source • switches • CRO • logic gates

6.0 MATTER

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (SKILLS, ATTITUDES AND KNOWLEDGE)	SUGGESTED LEARNING ACTIVITIES AND NOTES	SUGGESTED RESOURCES
6.1 Phases of Matter	• relate the difference in the structures and densities of solids, liquids and gases to simple ideas of the spacing, ordering and motion of molecules • describe a simple kinetic model for solids, liquids and gases • distinguish between the process of melting, boiling and evaporation • define the term pressure and using the kinetic model explain the pressure exerted by gases • derive, from the definitions of pressure and density the equation $p = pgh$ • use the equation $p = pgh$.	• Density • States of matter • Change of phase • Pressure in fluids	• Carrying out experiment to observe the random movement of molecules. • Carrying out experiments to determine the pressure due to a liquid column.	• transparent glass tube • Ice Cube • Laboratory thermometer • A beaker • Bunsen burner
6.2 Deformation of Solids	▪ explainhow the deformation is a result of deformation tensile or compressive ▪ describe the behaviour of springs in terms of load, extension, elastic limit, Hooke's law and the spring constant (i.e. force per unit extension)	▪ Stress, σ, strain,ϵ. ▪ Elastic and plastic behavior	• Carrying out experiments to determine the spring constant for springs connected in series and in parallel	• Helical springs • Clamps • stands

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (SKILLS, ATTITUDES AND KNOWLEDGE)	SUGGESTED LEARNING ACTIVITIES AND NOTES	SUGGESTED RESOURCES
	▪ define and use the terms stress, strain and the Young modulus ▪ describe an experiment to determine the Young Modulus of a metal in the form of a wire ▪ distinguish between elastic and plastic deformation of a material ▪ deduce the strain energy in a deformed material from the area under the force-extension graph ▪ sketch and compare the force-extension graphs for the typical ductile, brittle and polymeric materials, (consider ultimate tensile stress) ▪ explain fatigue as a consequence of cyclic stress insufficient to cause immediate failure, describe situations which lead to fatigue failure ▪ describe creep as failure due to sustained stress, below that required for immediate failure, combined with elevated temperature ▪ demonstrate knowledge with reference to properties of materials to the solving of simple engineering problems	▪ Young Modulus, E ▪ Force extension graph ▪ Structure and metals ▪ Deterioration and failure	• Loading materials to identify plastic and elastic behavior • Sketching graphs. • Visiting engineering companies	• different materials • rubber bands • coat hanger wire • Resource persons • ICT tools
6.3 Temperature	▪ show that a physical property which varies with temperature may be used for the measurement of temperature and state examples of such properties ▪ use the equation $\frac{\theta}{100} = \frac{x_\theta - x_o}{x_{100} - x_o}$ to calibrate a thermometer where X is a proportionally varying physical property ▪ explain the principal features and operation of a liquid-in-glass, resistance, constant-volume gas and thermocouple thermometers and state the advantages	▪ Temperature scales ▪ Fixed points ▪ Thermometric properties	• measuring the e.m.f of a thermocouple and using it to determine the temperature associated with the e.m.f • Discussing different types of thermometers	• thermocouple • Bunsen burner • Ice • Liquid in glass • Resistance thermometer • Constant volume gas

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (SKILLS, ATTITUDES AND KNOWLEDGE)	SUGGESTED LEARNING ACTIVITIES AND NOTES	SUGGESTED RESOURCES
	and disadvantages of each ▪ describe the thermodynamic scale and explain the concept of absolute zero. (Existence of an absolute scale of temperature which does not depend on the property of any particular substance) ▪ express temperatures in Kelvin and degree Celsius	▪ Types of thermometers		
6.4 Thermal Properties of Materials	▪ relate a rise in temperature of a body to an increase in internal energy ▪ define and use specific heat capacity, and show an awareness of the principles of its determination by electrical methods or any other suitable method ▪ define and use specific latent heat, and show an awareness of the principles of its determination by electrical methods ▪ describe and explain the cooling which accompanies evaporation both in terms of specific latent heat and in terms of the escape of high energy molecules ▪ explain that internal energy is determined by the state of the system and can be expressed as the sum of a random distribution of kinetic and potential energies associated with the molecules of a system ▪ state the first law of thermodynamics expressed in terms of the changes in internal energy, the heating of the system and the work done on the system	▪ Specific heat capacity ▪ Specific latent heat ▪ Internal energy ▪ First law of thermodynamics	• carrying out experiments to determine the nature of the cooling curve for metallic samples and other materials • Determining specific latent heat of fusion and vaporization. • Determining the specific heat capacity of a liquid and a solid using electrical methods or any other suitable method. • Simulating internal energy using ICT	• samples of different materials • thermometer • heating element • stopwatch • ammeter • voltmeter • electronic balance • bomb calorimeter
6.5 Ideal Gases	▪ list the assumptions of the kinetic theory of gases	▪ Kinetic theory of gases ▪ Equation of state	• measuring the pressure of gas from a gas cylinder	• gas cylinders • U-tube

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (SKILLS, ATTITUDES AND KNOWLEDGE)	SUGGESTED LEARNING ACTIVITIES AND NOTES	SUGGESTED RESOURCES
	▪ state and use the equation of state for an ideal gas expressed as $pV = nRT$(n = number of moles) ▪ explain how molecular movement causes the pressure exerted by a gas and provide a simple derivation of $p = \frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$($N$ = number of molecules) ▪ compare $p = \frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$ with $pV=NkT$ and hence deduce that the average translational kinetic energy of a molecule is proportional to T ▪ calculate work done by an ideal gas from p - V graphs	▪ Pressure of a gas ▪ Kinetic energy of a molecule ▪ Work done by an ideal gas	using a manometer • Solving problems using the equation of state • comparing different pressures from two different sources of gas • Deriving $p = \frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$ • Determining work done by ideal gas.	manometer • meter rule
6.6 Non-Viscous Fluid Flow	▪ explain what is meant by the terms steady (laminar, streamline) flow, incompressible flow, non-viscous flow, as applied to the motion of an ideal fluid ▪ explain how the velocity vector of a particle in an ideal fluid in motion is related to the streamline associated with that particle ▪ describe how streamlines can be used to define a tube of flow ▪ derive and use the equation *Av=constant* (the equation of continuity) for the flow of an ideal, incompressible fluid ▪ prove that the equation of continuity is a form of the principle for conservation of mass ▪ explain how pressure differences can arise from different rates of flow of a fluid (the Bernoulli effect) ▪ derive the Bernoulli equation in the form $p_1 + \frac{1}{2}pv_1^2 = p_2 + \frac{1}{2}pv_2^2$	▪ Ideal fluids in motion ▪ Streamlines and the equation of continuity ▪ Horizontal streamline ▪ The Bernoulli effect	▪ Using ICT simulation to show that Av=constant. ▪ Visiting airports to consult with resource persons to explain aerofoil motion ▪ Investigating the effect of creating a partial vacuum ▪ Solving problems using $p_1 + \frac{1}{2}pv_1^2 = p_2 + \frac{1}{2}pv_2^2$	• resource person • ICT tools • Pitot tube

TOPIC	OBJECTIVES Learners should be able to:	UNIT CONTENT (SKILLS, ATTITUDES AND KNOWLEDGE)	SUGGESTED LEARNING ACTIVITIES AND NOTES	SUGGESTED RESOURCES
	for the case of a horizontal tube to flow ▪ show that the Bernoulli equation is a form of the principle of conservation of mass ▪ explain how the Bernoulli effect is applied in the filter pump, in the Venturi meter, in atomizers and in the flow of air over an aerofoil		▪ Using ICT simulation to show how atomizers operate. ▪ Using Pitot tube to measure velocity	
6.7 Transfer of Thermal Energy	▪ demonstrate that thermal energy is transferred from a region of higher temperature to a region of low temperature ▪ state and explain the Zeroth law of thermo-dynamics ▪ explain the process of convection as a consequence of change of density ▪ demonstrate a qualitative understanding that bodies emit electromagnetic radiation at a rate which increases with increasing temperature ▪ describe simple applications involving the transfer of thermal energy by conduction, convection and radiation	▪ Thermal equilibrium ▪ Thermal conduction ▪ Convection ▪ Radiation	▪ investigating the direction of heat flow based on temperature gradient ▪ simulating emission of electromagnetic radiation	• ICT tools • thermometer • various materials

7.1 MODERN PHYSICS

TOPIC	OBJECTIVES Learners should be able to :	UNIT CONTENT (SKILLS, ATTITUDES AND KNOWLEDGE)	SUGGESTED LEARNING ACTIVITIES AND NOTES	SUGGESTED RESOURCES
7.1 Charged Particles	▪ interpret the experimental evidence for quantization of change ▪ understand the principles of determination of charge e by Millikan's experiment ▪ describe and analyze quantitatively using	▪ Electrons	▪ carrying out experiments to show the deflection of electrons	• vacuum tube • electron gun • permanent magnets • ICT tools
	▪ the deflection of beams of charged particles by uniform electric and uniform magnetic fields	▪ Beams of charged particles	▪ Carrying out calculations involving charged particles in uniform fields.	
	▪ explain how electric and magnetic fields can be used in velocity selection	▪ Crossed fields		
	▪ explain the principles of one method for the determination of v and e/m_e for electrons	▪ Mass spectrometry	▪ Explaining methods for the determination of v and e/m_e	

TOPIC	OBJECTIVES Learners should be able to :	UNIT CONTENT (SKILLS, ATTITUDES AND KNOWLEDGE)	SUGGESTED LEARNING ACTIVITIES AND NOTES	SUGGESTED RESOURCES
7.2 Quantum Physics	▪ explain the particulate nature of electromagnetic radiation ▪ state and use $E = hf$ ▪ describe the phenomena of the photoelectric effect ▪ describe the significance of threshold frequency ▪ explain why the maximum photoelectric energy is independent of intensity, and why the photoelectric current is proportional to intensity ▪ explain photoelectric phenomena in terms of photon energy and work function energy ▪ use and explain the significance of $hf = ø + ½mv^2_{max}$. ▪ explain the photoelectric effect as evidence for the particulate nature of electromagnetic radiation while phenomena such as interference and diffraction provides evidence for a wave nature ▪ describe and interpret qualitatively the evidence provided by electron diffraction for the wave nature of particles ▪ derive and use the relation for the de Broglie wavelength $\lambda = h/p$ ▪ explain the existence of discrete electron energy levels in isolated atoms (e.g. atomic hydrogen) and explain how this leads to spectral lines ▪ distinguish between emission and absorption line spectra ▪ state and use the relation $hf = E_1 - E_2$.	▪ Energy of a photon ▪ Photoelectric emission of electrons ▪ Wave particle duality ▪ Energy levels in atoms ▪ Line spectra	▪ Demonstrating photoelectric emission using a charged gold leaf and a suitable metal and Electromagnetic radiation ▪ simulating to show energy levels	• gold leaf electroscope • UV source • metal plates • Computer • ICT tools

TOPIC	OBJECTIVES Learners should be able to :	UNIT CONTENT (SKILLS, ATTITUDES AND KNOWLEDGE)	SUGGESTED LEARNING ACTIVITIES AND NOTES	SUGGESTED RESOURCES
7.3 Atomic Structure	▪ describe qualitatively the α - particle scattering experiment and the evidence it provides for the existence and small size of the nucleus ▪ use the usual notation of the presentation of nuclides ▪ show an appreciation of the association between energy and mass as represented by E = mc2 ▪ Illustrate graphically the variation of binding energy per nucleon with nucleon number ▪ describe the relevance of binding energy per nucleon to nuclear fusion and to nuclear fission ▪ verify that nucleon number, proton number, energy and mass are all conserved in nuclear processes ▪ represent simple nuclear reactions by nuclear equations of the form ▪ $^{14}_{7}N + {}^{4}_{2}He \rightarrow {}^{17}_{8}O + {}^{1}_{1}H$	▪ The nuclear atom ▪ The nucleus ▪ Isotopes ▪ Mass excess and nuclear binding energy ▪ Nuclear processes	▪ Describing the size of the nucleus ▪ Simulation ▪ Sketching a graph to show variation of binding energy per nucleon with nucleon number ▪ Balancing nuclide equations	• ICT tools

TOPIC	OBJECTIVES **Learners should be able to :**	UNIT CONTENT (SKILLS, ATTITUDES AND KNOWLEDGE)	SUGGESTED LEARNING ACTIVITIES AND NOTES	SUGGESTED RESOURCES
7.4 Radioactivity	▪ explain the spontaneous and random nature of nuclear decay ▪ describe the scientific and environmental importance of background radiation with reference to its existence and origin ▪ illustrate the random nature of radioactive decay by observation of the fluctuations in count rate ▪ describe the environmental hazards of ionizations and the safety ▪ list precautions which should be taken in the handling and disposal of radioactive material ▪ define the terms activity and decay constant and use $A = \lambda N$ ▪ recognize, use and represent graphically solutions of the decay law based on $x = x_0 \exp(-\lambda t)$ ▪ define half-life ($t_{½}$) ▪ use the relation $\lambda = (\ln 2)/t_{½}$ ▪ describe the use of radioisotopes, providing one example of each of the following: the use of tracers, the use of penetrating properties of radiation, the use ofionizing radiation in radiotherapy and leak detection	▪ Types of ionizing radiation ▪ Background radiation ▪ Hazards and safety precautions ▪ Radioactive decay ▪ Radioisotopes	▪ Simulating nuclear decay ▪ Discussing nature of nuclear decay ▪ Solving problems using the listed formulae ▪ Measuring background radiation ▪ Visiting industries which make use of radio activity ▪ Discussing procedures in the handling and disposal of radioactive waste.	• ICT tools • Resource persons • GM tube

TOPIC	**OBJECTIVES** **Learners should be able to :**	**UNIT CONTENT (SKILLS, ATTITUDES AND KNOWLEDGE)**	**SUGGESTED LEARNING ACTIVITIES AND NOTES**	**SUGGESTED RESOURCES**
7.5 **Communication**	▪ appreciate that information may be carried by a number of different channels, including wire-pairs, coaxial cables, radio and microwave links, optic fibres ▪ define the term modulation and be able to distinguish between amplitude modulation (AM) and frequency modulation (FM) ▪ recall that a carrier wave, amplitude modulated by a single audio frequency, is equivalent to the carrier wave frequency together with two sideband frequencies ▪ understand the term bandwidth ▪ recall the frequencies and wavelengths used in different channels of communication ▪ demonstrate an awareness of the relative advantages of AM and FM transmissions ▪ state the advantages of the transmission of data in digital form, compared with the transmission of data in analogue form ▪ understand that the digital transmission of speech or music involves analogue-to-digital conversion (ADC) before transmission and digital-to-analogue conversion (DAC) after reception ▪ understand the effect of the sampling rate and the number of bits in each sample on the reproduction of an input signal ▪ discuss the relative advantages and disadvantages of channels of communication in terms of available	▪ Communication Channels ▪ Modulation ▪ Digital Communication ▪ Relative merits of channels of communication ▪ Attenuation	▪ Visiting Broadcasting stations. ▪ Comparing transmissions of data in digital form and analog form	• ICT tools • Resource persons • Encoders • Decorders

TOPIC	OBJECTIVES Learners should be able to :	UNIT CONTENT (SKILLS, ATTITUDES AND KNOWLEDGE)	SUGGESTED LEARNING ACTIVITIES AND NOTES	SUGGESTED RESOURCES
	bandwidth, noise, crosslinking, security, signal attenuation, repeaters and regeneration ▪ recall the relative merits of both geostationary and polar orbiting satellites for communicating information ▪ understand and use signal attenuation expressed in dB and dB per unit length ▪ recall and use the expression *number of dB* = 10 $\log(P_1/P_2)$ for the ratio of two powers		▪ Inviting resource persons who know deal with satellite	

9.0 ASSESSMENT

Candidates for Advanced Level certification take Papers 1, 2, 3, 4 and 5 in a single examination series. Candidates may onlyenter for all the five papers per sitting. Papers 1, 2, 3 and 4 are externally assessed while Paper 5 is assessed internally. The syllabus is examined in May/June and October/November. Those who sit the October/November examination series are allowed to carry forward their Paper 5(continuous assessment mark) to the next May/June examination. The May/June examination series for this subject will not be available to school candidates.

(a) Assessment Objectives

The assessment objectives listed below reflect those parts of the syllabus aims that will be assessed in the examination.

Skill A: Knowledge with understanding

Candidates should be able to demonstrate knowledge and understanding of:
- scientific phenomena, facts, laws, definitions, concepts and theories
- scientific vocabulary, terminology and conventions (including symbols, quantities and units)
- scientific instruments and apparatus, including techniques of operation and aspects of safety
- scientific quantities and their determination
- scientific and technological applications with their social, economic and environmental implications.

The syllabus content defines the factual knowledge that candidates may be required to recall and explain.

Skill B: Handling, applying and evaluating information

Candidates should be able (in words or by using symbolic, graphical and numerical forms of presentation) to:
- locate, select, organise and present information from a variety of sources
- translate information from one form to another
- manipulate numerical and other data
- use information to identify patterns, report trends, draw inferences and report Conclusions
- present reasoned explanations for phenomena, patterns and relationships
- make predictions and put forward hypotheses
- apply knowledge, including principles, to new situations
- evaluate information and hypotheses
- demonstrate an awareness of the limitations of physical theories and models.

In answering such questions, candidates are required to use principles and concepts that are within the syllabus and apply them in a logical, reasoned or deductive manner to a new situation

Skill C: Experimental skills and investigations

Candidates should be able to:

1. plan experiments and investigations:
   - defining the problem
   - choice of equipment and procedure
   - data collection methods
   - good design features

2. collect, record and present observations, measurements and estimates

3. analyse and interpret data to reach conclusions

4. evaluate methods and quality of data, and suggest improvements.

The questions may be based on physics not included in the syllabus content, but candidates will be assessed on their practical skills rather than their knowledge of theory.

(b) Scheme of Assessment

Paper 1: Multiple Choice 1 hour

This paper consists of 40 multiple choice questions, all with four options. Candidates will answer all questions. Candidates will answer on an answer sheet. [40 marks]

Paper 2: Structured Questions 1 hour 30 minutes

This paper consists of a variable number of questions of variable mark value. Candidates will answer all questions. Candidates will answer on the question paper. [60 marks]

Paper 3: Free Response Questions 2 hours

This paper consists of 5free response questions. Each question carries 25 marks.
Question 1 covers General Physics and Newtonian Mechanics,
Question 2 covers Oscillations and Waves,
Question 3 covers Electricity and Magnetism,
Question 4 covers Matter and
Question 5 covers Modern Physics.

Candidates will answer question 1 and any three questions from the remaining 4 questions. Question 1 is compulsory. Candidates will answer on separate answer sheets. [100 marks]

Paper 4: Practical Skills:2 hours

This paper requires candidates to carry out practical work in timed conditions. The paper will consist of two experiments and one design practical drawn from different areas of Physics. The candidates will be assessed on their practical skills rather than their knowledge of theory. Candidates will answer all questions. Candidates will answer on the question paper. [50 marks]

Paper 5: Continuous Assessment

Continuous assessment will be done at the schools from term 1 of Form 5 to the end of term 2 of Form 6. Continuous assessment comprises of Theory tests, Practical tests and a Project. Teachers will be responsible for the continuous assessment of their candidates.

One continuous assessment theory test is administered at the end of each of the 32 topics. The standard of each test should be 50% skill A and 50% skill B.Each test carries 20 marks. [The total possible mark is weighted to 35 marks]

Two continuous assessment practical tests are administered per term from term 2 of Form 5 to term 2 of Form 6. The standard of each practical test is 100% skill C.[The total possible mark is weighted to 35 marks]

Paper	Type of Paper	Duration	Marks	Weight %
1	Multiple Choice	1hr	40	11
2	Structured	1hr 30minutes	60	17
3	Free response	2hr 30minutes	100	28
4	Practical	2hr 30minutes	50	14
5	Continuous assessment	Form 5 - 6	***110**	30

* The final total mark possible for continuous assessment is weighted to 110 marks

(c) Specification grid
The relationship between assessment objectives/skills and the Papers of the subject is as follows:

Paper	Skill A	Skill B	Skill C	Total Marks
1	18	22	0	40
2	25	35	0	60
3	45	55	0	100
4	0	0	50	50
5	24	23	63	*110
TOTAL				**360**

***The final total mark possible for continuous assessment is weighted to 110 marks**

10. 0 APPENDIX

MATHEMATICAL REQUIREMENTS

Arithmetic
Candidates should be able to:

recognise and use expressions in decimal and standard form (scientific) notation
recognise and use binary notation
use an electronic calculator for addition, subtraction, multiplication and division. Find arithmetic means, powers (including reciprocals and square roots), sines, cosines, tangents (and the inverse functions), exponentials and logarithms (lg and ln)
take account of accuracy in numerical work and handle calculations so that significant figures are neither lost unnecessarily nor carried beyond what is justified
make approximate evaluations of numerical expressions (e.g. π2 ≈ 10) and use such approximations to check the magnitude of calculated results.

Algebra

Candidates should be able to:
change the subject of an equation. Most relevant equations involve only the simpler operations but may include positive and negative indices and square roots.
solve simple algebraic equations. Most relevant equations are linear but some may involve inverse and inverse square relationships. Linear simultaneous equations and the use of the formula to obtain the solutions of quadratic equations are required.
substitute physical quantities into physical equations using consistent units and check the dimensional consistency of such equations
set up simple algebraic equations as mathematical models of physical situations, and identify inadequacies of such models
recognise and use the logarithms of expressions like ab, a b, xn, ekx and understand the use of logarithms in relation to quantities with values that range over several orders of magnitude

express small changes or uncertainties as percentages and vice versa
understand and use the symbols <, >, ≤, ≥, «, », /, □, <x>, Σ, Δx, δx, √

Geometry and trigonometry

Candidates should be able to:
calculate areas of right-angled and isosceles triangles, circumference and area of circles, areas and volumes of cuboids, cylinders and spheres
use Pythagoras' theorem, similarity of triangles, the angle sum of a triangle
use sines, cosines and tangents of angles (especially for 0°, 30°, 45°, 60°, 90°)
use the trigonometric relationships for triangles:
Sine rule
Cosine rule
use $\sin\theta \approx \tan\theta \approx \theta$ and $\cos\theta \approx 1$ for small θ ;$\sin 2\theta + \cos 2\theta = 1$
understand the relationship between degrees and radians, convert from one to the other and use the appropriate system in context.

Vectors

Candidates should be able to:

find the resultant of two coplanar vectors, recognising situations where vector addition is appropriate
obtain expressions for components of a vector in perpendicular directions, recognising situations where vector resolution is appropriate.

Graphs

Candidates should be able to:
translate information between graphical, numerical, algebraic and verbal forms
select appropriate variables and scales for graph plotting
determine the gradient, intercept and intersection of linear graphs
choose, by inspection, a straight line which will serve as the line of best fit through a set of data points presented graphically
draw a curved trend line through a set of data points presented graphically, when the arrangement of these data points is clearly indicative of a non-linear relationship
recall standard linear form $y = mx + c$ and rearrange relationships into linear form where appropriate
sketch and recognise the forms of plots of common simple expressions like 1/x , x^2, 1/x^2, sinx, cosx, e^(-x)
draw a tangent to a curve, and understand and use the gradient of the tangent as a means to obtain the gradient of the curve at a point
understand and use the area below a curve where the area has physical significance.

Treatment of uncertainties

Candidates should be able to:
convert absolute uncertainty estimates into fractional or percentage uncertainty estimates and vice versa
show uncertainty estimates, in absolute terms, beside every value in a table of results
calculate uncertainty estimates in derived quantities
show uncertainty estimates as error bars on a graph
estimate the absolute uncertainty in the gradient of a graph by recalling that absolute uncertainty = gradient of line of best fit – gradient of worst acceptable line
estimate the absolute uncertainty in the y-intercept of a graph by recalling that absolute uncertainty = y-intercept of line of best fit – y-intercept of worst acceptable line
express a quantity as a value, an uncertainty estimate and a unit.

Summary of key quantities, symbols and units

Quantity	Usual symbols	Usual unit
Base quantities		
mass	m	kg
length	l	m
time	t	s
electric current	I	A
thermodynamic temperature	T	K
amount of substance	n	mol

Quantity	Usual symbols	Usual unit
electric field strength	E	$\mathrm{N\,C^{-1}}$, $\mathrm{V\,m^{-1}}$
electric potential	V	V
electric potential difference	V	V
electromotive force	E	V
electron mass	m_e	kg, u
elementary charge	e	C
energy	E, U, W	J
force	F	N
frequency	f	Hz
gravitational constant	G	$\mathrm{N\,m^2\,kg^{-2}}$
gravitational field strength	g	$\mathrm{N\,kg^{-1}}$
gravitational potential	ϕ	$\mathrm{J\,kg^{-1}}$
half-life	$t_{\frac{1}{2}}$	s
Hall voltage	V_H	V
heating	q, Q	J
intensity	I	$\mathrm{W\,m^{-2}}$
internal energy change	ΔU	J
kinetic energy	E_k	J
magnetic flux	Φ	Wb
magnetic flux density	B	T
mean-square speed	$\langle c^2 \rangle$	$\mathrm{m^2\,s^{-2}}$
molar gas constant	R	$\mathrm{J\,mol^{-1}\,K^{-1}}$
molar mass	M	$\mathrm{kg\,mol^{-1}}$
moment of force	T	N m
momentum	p	N s
neutron mass	m_n	kg, u
neutron number	N	
nucleon number	A	
number	N, n, m	
number density (number per unit volume)	n	$\mathrm{m^{-3}}$
period	T	s
permeability of free space	μ_0	$\mathrm{H\,m^{-1}}$
permittivity of free space	ε_0	$\mathrm{F\,m^{-1}}$

Quantity	Usual symbols	Usual unit
power	P	W
pressure	p	Pa
proton mass	m_p	kg, u
proton number	Z	
ratio of powers		dB
relative atomic mass	A_r	
relative molecular mass	M_r	
resistance	R	Ω
resistivity	ρ	$\Omega\,m$
specific acoustic impedance	Z	$kg\,m^{-2}\,s^{-1}$
specific heat capacity	c	$J\,kg^{-1}\,K^{-1}$
specific latent heat	L	$J\,kg^{-1}$
speed	u, v, w, c	$m\,s^{-1}$
speed of electromagnetic waves	c	$m\,s^{-1}$
spring constant	k	$N\,m^{-1}$
strain	ε	
stress	σ	Pa
torque	T	N m
velocity	u, v, w, c	$m\,s^{-1}$
volume	V, v	m^3
wavelength	λ	m
weight	W	N
work	w, W	J
work function energy	Φ	J
Young modulus	E	Pa

Other quantities		
acceleration	a	$m\,s^{-2}$
acceleration of free fall	g	$m\,s^{-2}$
activity of radioactive source	A	Bq
amplitude	x_0	m
angle	θ	°, rad
angular displacement	θ	°, rad
angular frequency	ω	$rad\,s^{-1}$
angular speed	ω	$rad\,s^{-1}$
angular velocity	ω	$rad\,s^{-1}$
area	A	m^2
atomic mass	m_a	kg, u
attenuation/absorption coefficient	μ	m^{-1}
Avogadro constant	N_A	mol^{-1}
Boltzmann constant	k	$J\,K^{-1}$
capacitance	C	F
Celsius temperature	θ	°C
decay constant	λ	s^{-1}
density	ρ	$kg\,m^{-3}$
displacement	s, x	m
distance	d	m
efficiency	η	
electric charge	q, Q	C

Quantity	Usual symbols	Usual unit
electric field strength	E	$\mathrm{N\,C^{-1}}$, $\mathrm{V\,m^{-1}}$
electric potential	V	V
electric potential difference	V	V
electromotive force	E	V
electron mass	m_e	kg, u
elementary charge	e	C
energy	E, U, W	J
force	F	N
frequency	f	Hz
gravitational constant	G	$\mathrm{N\,m^2\,kg^{-2}}$
gravitational field strength	g	$\mathrm{N\,kg^{-1}}$
gravitational potential	ϕ	$\mathrm{J\,kg^{-1}}$
half-life	$t_{\frac{1}{2}}$	s
Hall voltage	V_H	V
heating	q, Q	J
intensity	I	$\mathrm{W\,m^{-2}}$
internal energy change	ΔU	J
kinetic energy	E_k	J
magnetic flux	Φ	Wb
magnetic flux density	B	T
mean-square speed	$\langle c^2 \rangle$	$\mathrm{m^2\,s^{-2}}$
molar gas constant	R	$\mathrm{J\,mol^{-1}\,K^{-1}}$
molar mass	M	$\mathrm{kg\,mol^{-1}}$
moment of force	T	N m
momentum	p	N s
neutron mass	m_n	kg, u
neutron number	N	
nucleon number	A	
number	N, n, m	
number density (number per unit volume)	n	$\mathrm{m^{-3}}$
period	T	s
permeability of free space	μ_0	$\mathrm{H\,m^{-1}}$
permittivity of free space	ε_0	$\mathrm{F\,m^{-1}}$

Quantity	Usual symbols	Usual unit
power	P	W
pressure	p	Pa
proton mass	m_p	kg, u
proton number	Z	
ratio of powers		dB
relative atomic mass	A_r	
relative molecular mass	M_r	
resistance	R	Ω
resistivity	ρ	Ω m
specific acoustic impedance	Z	$\mathrm{kg\,m^{-2}\,s^{-1}}$
specific heat capacity	c	$\mathrm{J\,kg^{-1}\,K^{-1}}$
specific latent heat	L	$\mathrm{J\,kg^{-1}}$
speed	u, v, w, c	$\mathrm{m\,s^{-1}}$
speed of electromagnetic waves	c	$\mathrm{m\,s^{-1}}$
spring constant	k	$\mathrm{N\,m^{-1}}$
strain	ε	
stress	σ	Pa
torque	T	N m
velocity	u, v, w, c	$\mathrm{m\,s^{-1}}$
volume	V, v	$\mathrm{m^3}$
wavelength	λ	m
weight	W	N
work	w, W	J
work function energy	Φ	J
Young modulus	E	Pa

(c) Glossary of Assessment command words

This glossary should prove helpful to candidates as a guide, although it is not exhaustive and it has deliberately been kept brief. Candidates should understand that the meaning of a term must depend in part on its context. The number of marks allocated for any part of a question is a guide to the depth required for the answer.

1. Define (the term(s) ...) is intended literally. Only a formal statement or equivalent paraphrase, such as the defining equation with symbols identified, is required.

2. What is meant by ... normally implies that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The number of marks indicated will suggest the amount of supplementary comment required.

3. Explain may imply reasoning or some reference to theory, depending on the context.

4. State implies a concise answer with little or no supporting argument, e.g. a numerical answer that can be obtained 'by inspection'.

5. List requires a number of points with no elaboration. If a specific number of points is requested, this number should not be exceeded.

6. Describe requires candidates to state in words (using diagrams where appropriate) the main points of the topic. It is often used with reference either to particular phenomena or to particular experiments. For particular phenomena, the term usually implies that the answer should include reference to (visual) observations associated with the phenomena. The amount of description intended is suggested by the indicated mark value.

7. Discuss requires candidates to give a critical account of the points involved in the topic.

8. Deduce/Predict implies that candidates are not expected to produce the required answer by recall, but by making a logical connection between other pieces of information. Such information may be wholly given in the question, or may depend on answers extracted in an earlier part of the question.

9. Suggest is used in two main contexts. It may imply either that there is no unique answer or that candidates are expected to apply their general knowledge to a new situation (one that may not, formally, be in the syllabus).

10. Calculate is used when a numerical answer is required. In general, working should be shown.

11. Measure implies that the quantity concerned can be directly obtained from a suitable measuring instrument, e.g. length, using a rule, or angle, using a protractor.

12. Determine often implies that the quantity concerned cannot be measured directly, but is obtained by calculation, substituting measured or known values of other quantities into a standard formula, e.g. the Young modulus, relative molecular mass.

13. Show is used where a candidate is expected to derive a given result. It is important that the terms being used by candidates are stated explicitly and that all stages in the derivation are stated clearly.

14. Estimate implies a reasoned order of magnitude statement or calculation of the quantity concerned. Candidates should make any necessary simplifying assumptions about points of principle and about the values of quantities not otherwise included in the question.
15. Sketch (applied to graph work) implies that the shape and/or position of the curve need only be qualitatively correct.
16. However, candidates should be aware that, depending on the context, some quantitative aspects may be looked

for, e.g. passing through the origin, having an intercept, asymptote or discontinuity at a particular value. On a sketch graph it is essential that candidates clearly indicate what is being plotted on each axis.

17. Sketch (applied to diagrams) implies that a simple, freehand drawing is acceptable, though care should be taken over proportions and the clear exposition of important details.

18. Compare requires candidates to provide both similarities and differences between things or concepts.

(D) Data and formulae

The following data and formulae will appear as pages 2 and 3 in Papers 1, 2 and 3.

DATA

speed of light in free space	c = 3.00 x $10^{8}\mathrm{ms}^{-1}$
permeability of free space	μ_o = 4π x 10^{-7} Hm^{-1}
permittivity of free space	ε_0 = 8.85 x 10^{-12} Fm^{-1} (1/ $4\pi\varepsilon_0$ = 8.99 x 10^{9} mF^{-1})
elementary charge	e = 1.60 x 10^{-19} C
the Planck constant	h = 6.63 x 10^{-34} Js
unified atomic mass unit	1 u = 1.66 x 10^{-27} kg
rest mass of electron	m_e = 9.11 x 10^{-31} kg
rest mass of proton	m_p = 1.67 x 10^{-27} kg
molar gas constant	R = 8.31 $\mathrm{JK}^{-1}\mathrm{mol}^{-1}$
the Avogadro constant	N_A = 6.02 x $10^{23}\mathrm{mol}^{-1}$
the Boltzmann constant	k = 1.38 x 10^{-23} JK^{-1}
gravitational constant	G = 6.67 x $10^{-11}\mathrm{Nm}^{2}\mathrm{kg}^{-2}$
acceleration of free fall	g = 9.81 ms^{-2}

FORMULAE

uniformly accelerated motion $s = ut + ½at^2$
$v^2 = u^2 + 2as$
work done on/by a gas $W = p\,\Delta V$
gravitational potential $\emptyset = -\,Gm/r$
hydrostatic pressure $p = \rho gh$
pressure of an ideal gas $p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
simple harmonic motion $a = -\omega^2 x$
velocity of particle in s.h.m. $v = v_o \cos \omega t$
$v = \pm\omega\sqrt{(x_o^2 - x^2)}$
Doppler effect $f_o = \frac{f_s v}{v \pm v_s}$
electric potential $V = \frac{Q}{4\pi\varepsilon_0 r}$
capacitors in series $1/C = 1/C_1 + 1/C_2 + \ldots$
capacitors in parallel $C = C_1 + C_2 + \ldots$
energy of charged capacitor $W = \frac{1}{2}QV$
electric current $I = Anvq$
resistors in series $R = R_1 + R_2 + \ldots$
resistors in parallel $1/R = 1/R_1 + 1/R_2 + \ldots$
Hall voltage $V_H = \frac{BI}{ntq}$
alternating current/voltage $x = x_o \sin\omega t$
radioactive decay $x = x_o \exp(-\lambda t)$
decay constant $\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

(E) Commonly Used Materials And Apparatus

The list is not exhaustive: other items are usually required, to allow for variety in the questions set.
Cells: 1.5 V
Connecting leads and crocodile clips
Digital ammeter, minimum ranges 0–1 A reading to 0.01 A or better, 0–200 mA reading to 0.1 mA or better, 0–20 mA reading to 0.01 mA or better (digital multimeters are suitable)
Digital voltmeter, minimum ranges 0–2 V reading to 0.001 V or better, 0–20 V reading to 0.01 V or better (digital multimeters are suitable)
Lamp and holder: 6 V 60 mA; 2.5 V 0.3 A
Power supply: variable up to 12 V d.c. (low resistance)
Rheostat (with a maximum resistance of at least 8 Ω, capable of carrying a current of at least 4 A)
Switch Wire: constantan 26, 28, 30, 32, 34, 36, 38 s.w.g. or similar metric sizes
Long stem thermometer: –10 °C to 110 °C × 1 °C
Means to heat water safely to boiling (e.g. an electric kettle)
Plastic or polystyrene cup 200 cm3
Stirrer
Adhesive putty (e.g. Blu-Tack)
Adhesive tape (e.g. Sellotape)
Balance to 0.1 g (this item may often be shared between sets of apparatus)
Bar magnet
Bare copper wire: 18, 20, 26 s.w.g. or similar metric sizes
Beaker: 100 cm3, 200 cm3 or 250 cm3
Card
Expendable steel spring (spring constant approx. 25 N m–1; unstretched length approx. 2 cm)
G-clamp
Magnadur ceramic magnets
Mass hanger
Micrometer screw gauge (this item may often be shared between sets of apparatus)
Modelling clay (e.g. Plasticine)
Newton-meter (1 N, 10 N)

Pendulum bob
Protractor
Pulley
Rule with a millimetre scale (1 m, 0.5 m, 300 mm)
Scissors Slotted masses (100 g, 50 g, 20 g, 10 g) or alternative Stand, boss and clamp
Stopwatch (candidates may use their wristwatches), reading to 0.1 s or better
Stout pin or round nail
String/thread/twine
Vernier or digital callipers (this item may often be shared between sets of apparatus)
Wire cutters